

Complete Larval Development of *Chiromantes haematocheir* (Crustacea: Decapoda: Brachyura: Grapsidae), with a Key to Seven Sesarminid Zoeas in Korea

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ABSTRACT

The complete larval development of *Chiromantes haematocheir* was obtained by laboratory rearing. Five zoeal and one megalopal stages are described and illustrated in detail. Morphological characteristics of the larvae slightly differ from those of Lee (1988), especially in the setal presence of mouthpart appendages. Seven sesarminid zoeas (*Parasesarma acis*, *Parasesarma pictum*, *Perisesarma bidens*, *Sesarmops intermedius*, *Chiromantes dehaani*, *Chiromantes haematocheir*, and *Nanosesarma gordonii*) can be distinguished from each other in characters of the carapace spines, the antennal exopod and the fork of telson. A provisional key is first provided to aid the identification of seven sesarminid zoeas in Korea.

Key words: *Chiromantes haematocheir*, larvae, zoea, key, Korea

INTRODUCTION

The subfamily Sesarminae is the most diverse of the family Grapsidae and 15 species are recorded from Korea (Kim, 1973; The Korean Society of Systematic Zoology, 1997). They can be found in a wide range of habitats and substrates. Especially, *Chiromantes haematocheir* (De Haan, 1833) inhabits swamps near the seashore or muddy banks of the freshwater stream (Sakai, 1976). It occurs on coasts of China, Formosa, Taiwan, Korea and Japan (Kim, 1973; Dai and Yang, 1991).

The larval descriptions of the subfamily Sesarminae have been existed for 14 species: *Nanosesarma gordonii* (Shen, 1935) by Terada (1982); *Parasesarma pictum* (De Haan, 1835) (= *Sesarma pictum*) by Aikawa (1937) and Lee (1988); *Parasesarma acis* Davie, 1993, [= *Sesarma erythrodactyla* (Hess, 1865)] by Terada (1976) and Kim and Ko (1985); *Sesarmops intermedius* (De Haan, 1835), *Perisesarma bidens* (De Haan, 1835) (= *Chiromantes bidens*) and *Parasesarma plicatum* (Latreille, 1803) by Terada (1976) and Fukuda and Baba (1976); *Chiromantes haematocheir* (= *Holometopus haematocheir*) by Fukuda and Baba (1976) and Lee (1988); *Chiromantes dehaani* (H. Milne Edwards, 1853) [= *Sesarma* (*Holometopus*) *dehaani*] by Baba and Miyata (1971); *Cyclograpsus intermedius* Ortmann, 1894, by Terada (1976) and Kim and Jang (1986); *Chasmagnathus convexus* De Haan, 1833, by Baba and Fukuda (1972);

Helice tridens De Haan, 1835, and *Helicana japonica* (K. Sakai and Yatsuzuka, 1980) (= *Helice tridens wuana* Rathbun, 1929) by Baba and Moriyama (1972); *Helice tientsinensis* Rathbun, 1931, by Kim and Park (1983); *Helice subquadrata* (Dana, 1851) (= *Helice leachi* Hess, 1865) by Baba et al. (1984). Although, the larval stage of *Chiromantes haematocheir* was first published by Fukuda and Baba (1976), this report was limited to the brief comments and without illustrations. Later, Lee (1988) described the larval development of it in her dissertation, which has not published yet. Moreover, some diagnostic setae were overlooked when she illustrated the larvae.

Therefore, the aims of this paper are to describe the complete larval stages including megalopal stage of *C. haematocheir* in detail, to compare its morphology with previously described zoeas of the subfamily Sesarminae, and to provide a key for the identification of seven sesarminid zoeas (*P. acis*, *P. pictum*, *P. bidens*, *S. intermedius*, *C. dehaani*, *C. haematocheir*, and *N. gordonii*) in Korea.

MATERIALS AND METHODS

An ovigerous *C. haematocheir* was collected in the high intertidal of exposed beach in Goseong-gun, Gyeongsangnam-do, Korea (34° 53'N; 128° 12'E), on 4 August 2006 and transported to a constant temperature chamber at Silla University, Busan. Zoeas hatched next day were reared using methods described by Ko (1995) at a constant water temperature of 25°C. Larvae were fixed and preserved in 10% neu-

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tral formalin. Larval specimens were dissected using Leitz zoom stereomicroscope and appendages were examined under a Leitz Laborlux S microscope. Appendages were mounted in polyvinyl lactophenol, cover slips were sealed with clear nail varnish and drawings were made with the aid of camera lucida. Setal counts and measurements were based on 10 specimens for each larval stage. The sequence of the larval description is based on the malacostracan somite plan and described from anterior to posterior. Setal armature of appendages was described from proximal to distal segments and in order of endopod to exopod (Clark et al., 1998). The larval stages were described and fully illustrated. For the second and subsequent larval stages only the main differences from the previous stage were described. The long plumose natatory setae of the first and second maxillipeds were drawn truncated. A micrometer was used for larval measurement of carapace length, measured from the base of the rostral spine to the most posterior carapace margin. The approximate measurement of the antennal exopod (for its ratio with the protopod) was taken from the base to the tip excluding the terminal setae. The approximate measurement of the fork of telson (for its ratio to the telson) was taken from the base of the posterior outmost seta to the tip of fork. The larval series and the spent females were deposited in Silla University, Korea (accession number: SUZ Cr103246).

RESULTS

Five zoeal stages appeared before metamorphosis to the megalopa. The mean duration of each zoeal stage at 25°C was 3 days. Metamorphosis to the megalopa occurred at least 16 days after the first stage zoeas hatched from eggs.

Chiromantes haematocheir (De Haan, 1833) (Figs. 1-6)

Zoea I

Size: Carapace length 0.40 ± 0.02 mm. Distance from tip of dorsal spine to tip of rostral spine 0.68 ± 0.03 mm.

Carapace (Fig. 1A). Dorsal spine long, slightly curved, longer than rostral spine; rostral spine straight, about equal in length to antennal protopod; lateral spine absent; pair of anterodorsal setae present; pair of posterodorsal setae present; each ventral margin without setae; eyes sessile.

Antennule (Fig. 1B). Uniramous; endopod absent; exopod unsegmented, with 5 (3 stout+2 thinner) aesthetascs and small seta terminally.

Antenna (Fig. 1C). Protopod slightly shorter than rostral spine, spinulate distally; exopod about 30% length to protopod, with 4 (1 long, 3 shorter) terminal setae. Endopod

absent.

Mandibles (Fig. 1D). Asymmetrical; right molar with 2 teeth and left molar with tooth, confluent with incisor process; endopod palp absent.

Maxillule (Fig. 1E). Coxal and basial endites both with 5 denticulate setae; endopod 2-segmented, proximal segment with seta, distal segment with 5 (1 subterminal+4 terminal) setae.

Maxilla (Fig. 1F). Coxal endite bilobed, with 4+3 setae; basial endite bilobed, with 5+4 setae; endopod bilobed, with 2+3 setae; exopod (scaphognathite) margin with 4 plumose setae plus distal stout process.

First maxilliped (Fig. 1G). Coxa with seta; basis with 10 setae arranged 2, 2, 3, 3; endopod 5-segmented, with 2, 2, 1, 2, 5 (1 subterminal+4 terminal) setae, respectively; exopod 2-segmented, distal segment with 4 terminal natatory plumose setae.

Second maxilliped (Fig. 1H). Coxa without seta; basis with 4 setae; endopod 3-segmented, with 0, 1, 6 (3 subterminal+3 terminal) setae, respectively; exopod 2-segmented, distal segment with 4 terminal natatory plumose setae.

Third maxilliped: Absent.

Abdomen (Fig. 1A, J). Five somites; somite 2 with pair of lateral processes directed anteriorly; somite 3 with pair of lateral processes directed posteriorly; somites 2-5 with pair of posterodorsal setae; pleopods absent.

Telson (Fig. 1I, J). Each fork long and spinulate, without seta, about 58% length to telson; posterior margin with 3 pairs of spinulate setae.

Zoea II

Size: Carapace length 0.47 ± 0.02 mm. Distance from tip of dorsal spine to tip of rostral spine 0.89 ± 0.05 mm.

Carapace (Fig. 2A). Two pairs of anterodorsal setae present.

Antennule (Fig. 2B). Exopod with 5 (3 stout+2 thinner) aesthetascs and small seta terminally.

Antenna (Fig. 2C). Unchanged.

Mandibles (Fig. 2D). Unchanged.

Maxillule (Fig. 2E). Basial endite with 7 denticulate setae; exopod seta present.

Maxilla (Fig. 2F). Exopod (scaphognathite) margin with 5+3 plumose setae.

First and second maxillipeds (Fig. 2G, H). Exopods both with 6 terminal natatory plumose setae.

Abdomen (Fig. 2I). Somite 1 with dorsomedial seta.

Telson (Fig. 2I). Unchanged.

Zoea III

Size: Carapace length 0.51 ± 0.05 mm. Distance from tip of dorsal spine to tip of rostral spine 1.00 ± 0.03 mm.

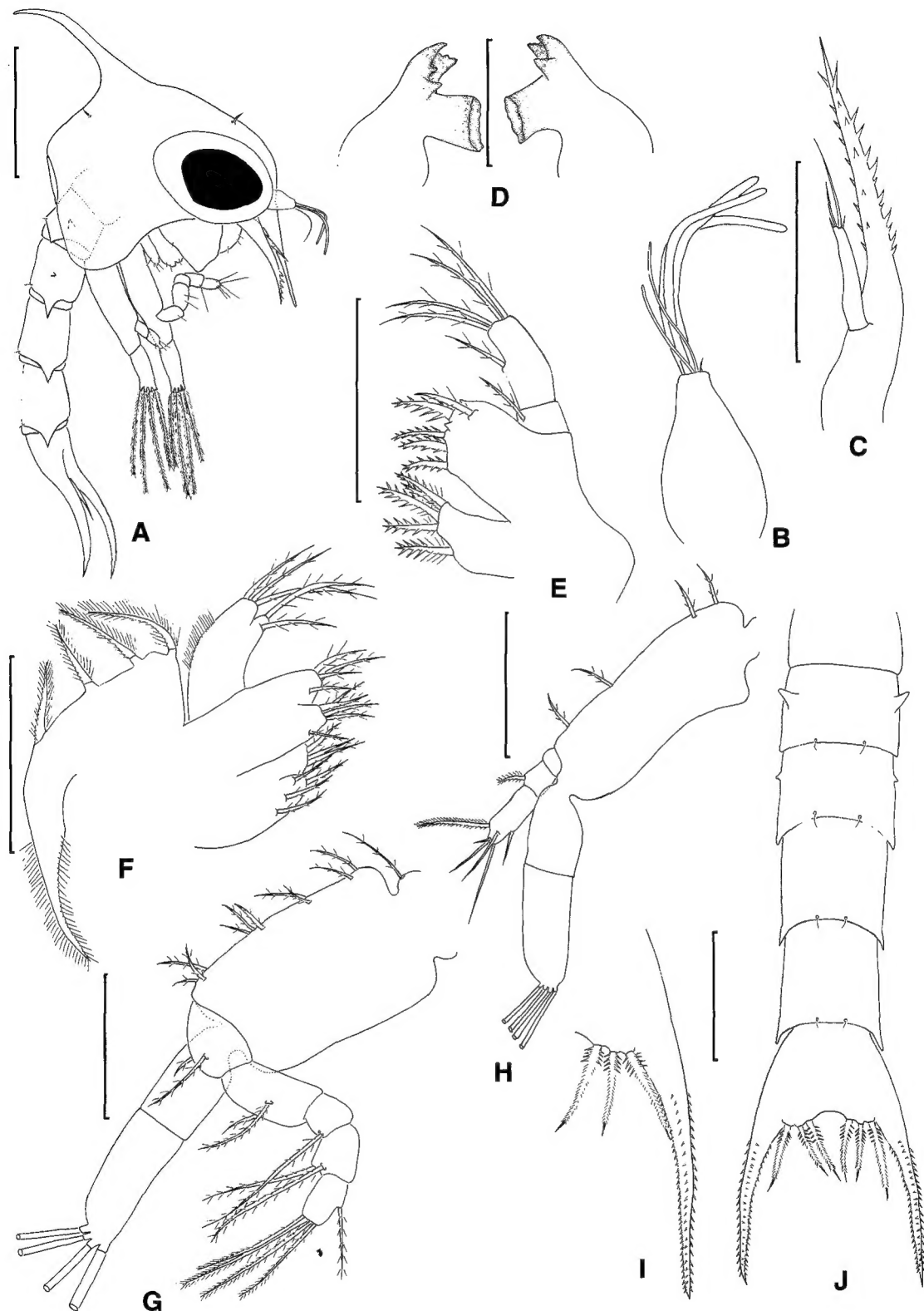


Fig. 1. *Chiromantes haematocheir*, first zoeal stage. A, lateral view; B, antennule; C, antenna; D, mandibles; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, telson; J, dorsal view of abdomen and telson. Scale bars=0.25 mm (A), 0.1 mm (B-J).

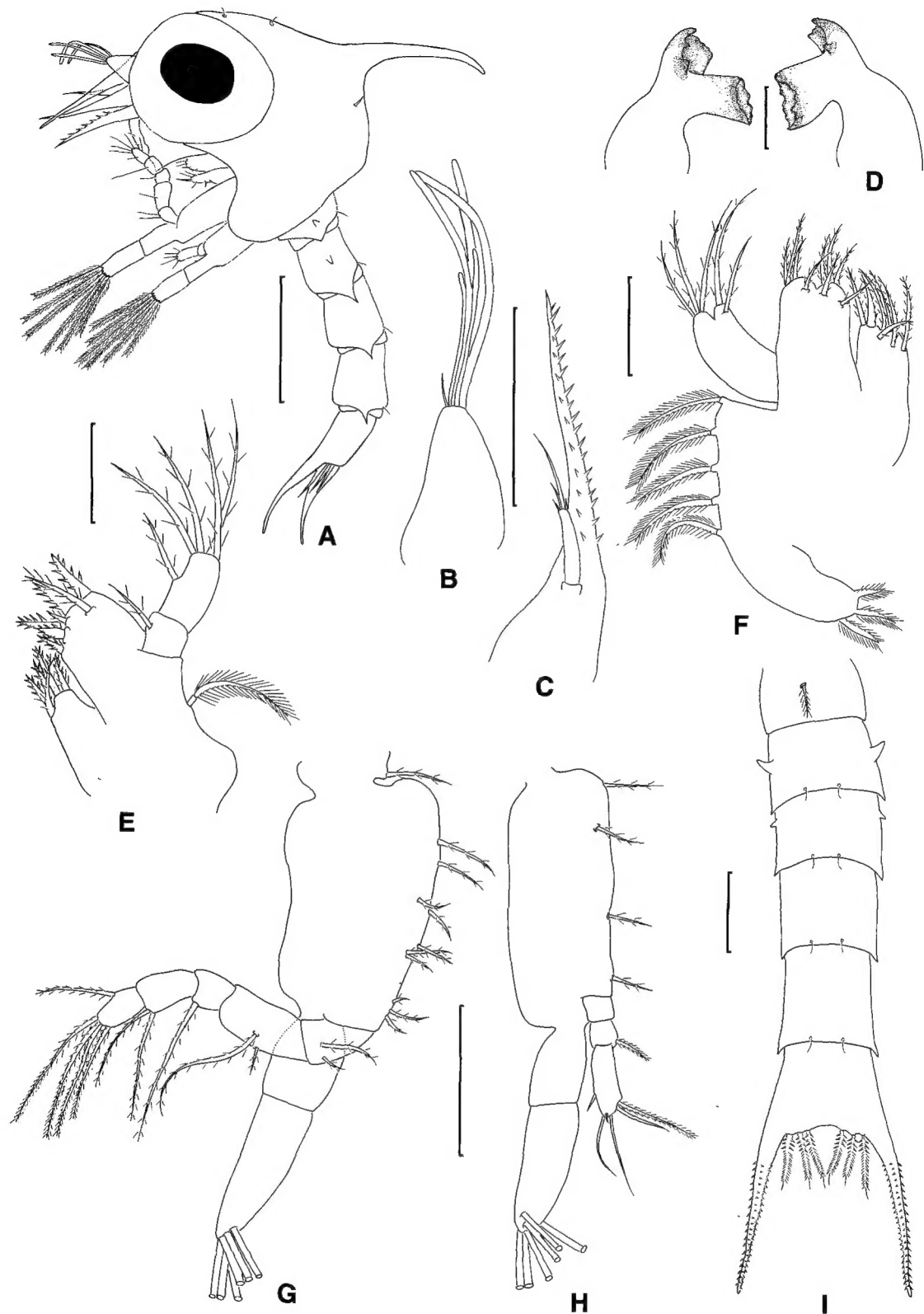


Fig. 2. *Chiromantes haematocheir*, second zoeal stage. A, lateral view; B, antennule; C, antenna; D, mandibles; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, dorsal view of abdomen and telson. Scale bars=0.25 mm (A), 0.1 mm (B, C, G-I), 0.05 mm (D-F).

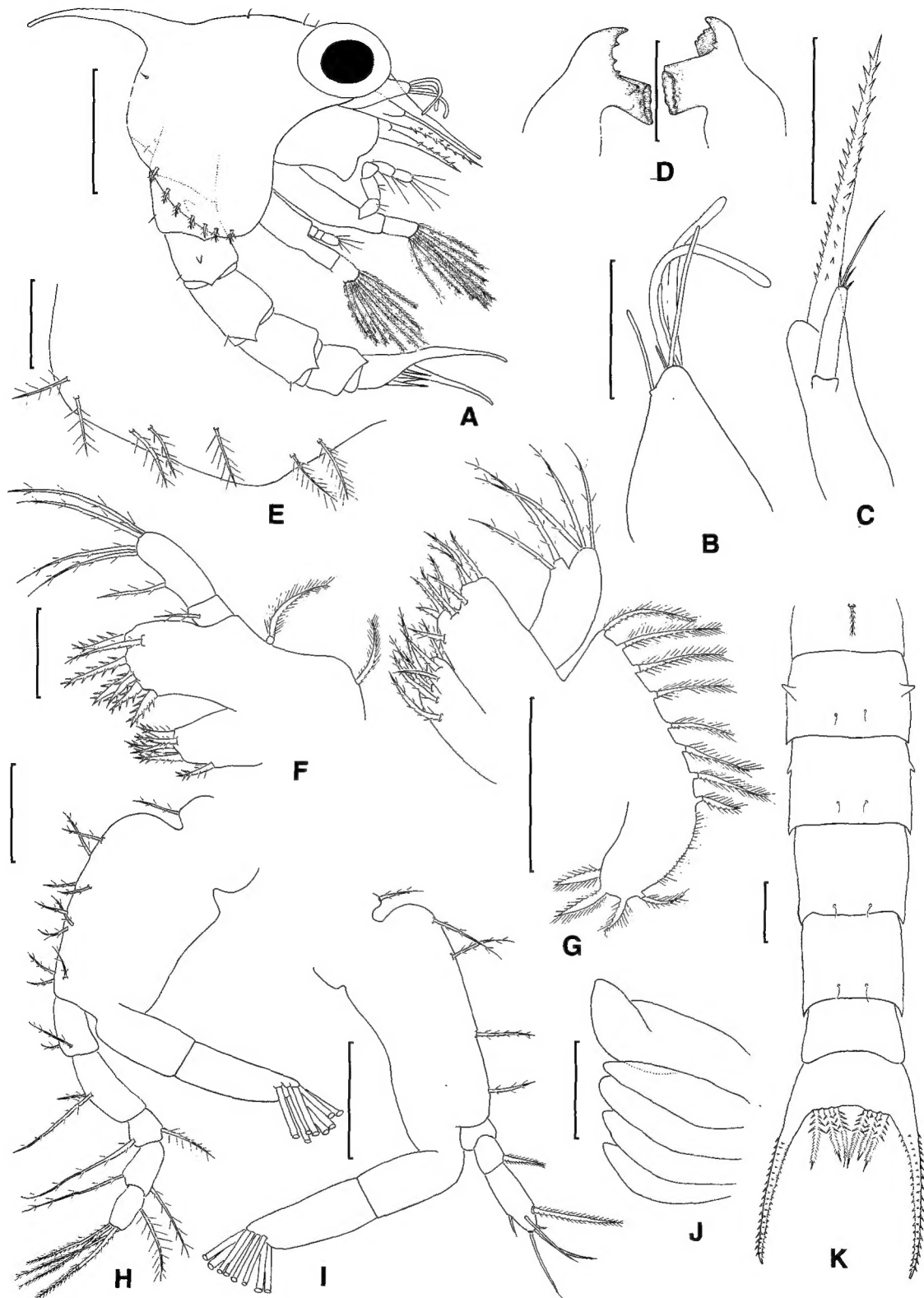


Fig. 3. *Chiromantes haematocheir*, third zoeal stage. A, lateral view; B, antennule; C, antenna; D, mandibles; E, lateral expansion of carapace; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped; J, pereopods; K, dorsal view of abdomen and telson. Scale bars=0.25 mm (A), 0.1 mm (B-E, G-K), 0.05 mm (F).

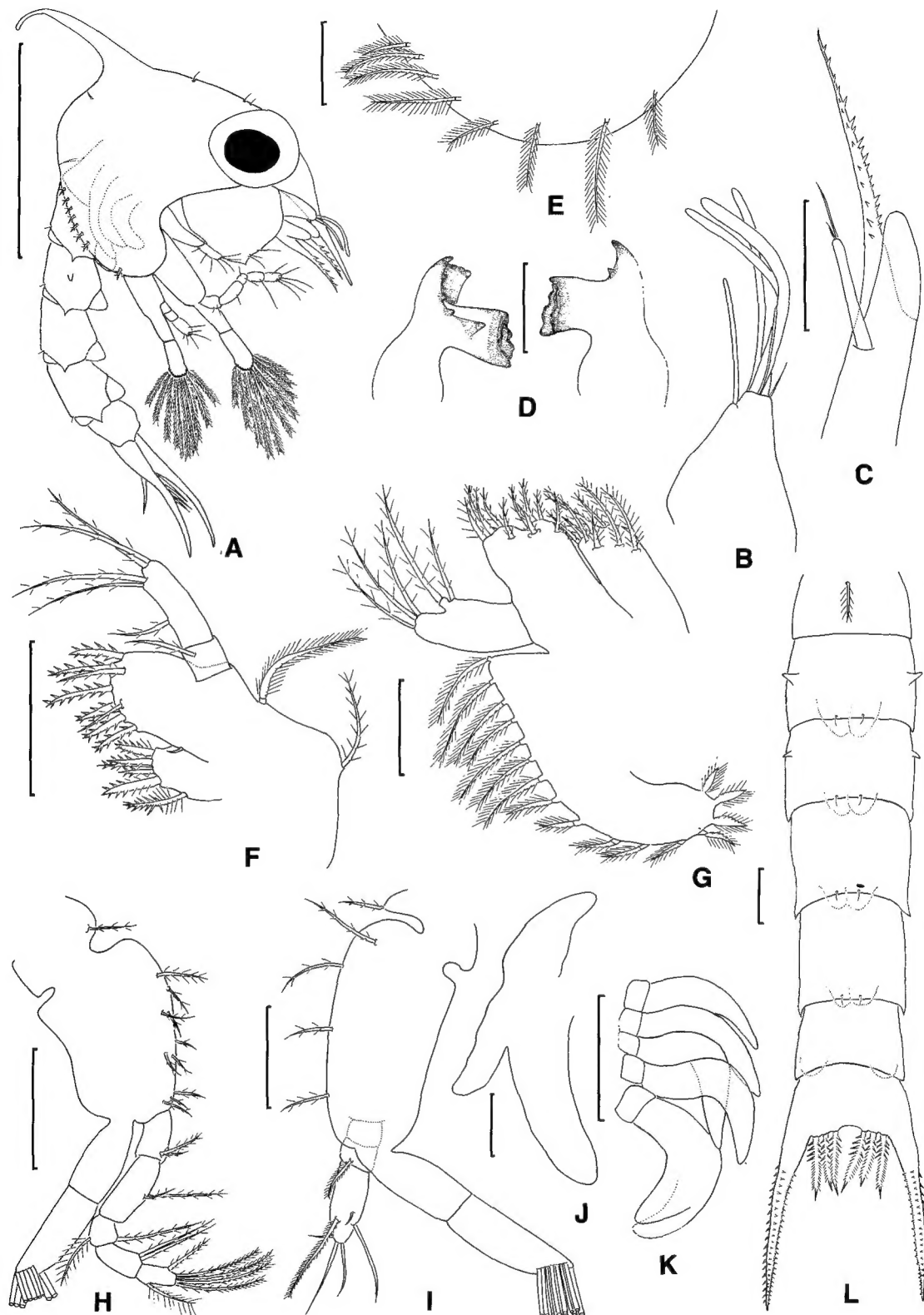


Fig. 4. *Chiromantes haematocheir*, fourth zoeal stage. A, lateral view; B, antennule; C, antenna; D, mandibles; E, lateral expansion of carapace; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped; J, third maxilliped; K, pereopods; L, dorsal view of abdomen and telson. Scale bars=0.5 mm (A), 0.1 mm (B-I, L), 0.05 mm (J), 0.25 mm (K).

Carapace (Fig. 3A, E). Three pairs of anterodorsal setae present; ventral margin with 7 setae.

Antennule (Fig. 3B). Exopod with 4 (2 stout+2 thinner) aesthetascs and small seta terminally, with aesthetasc subterminally.

Antenna (Fig. 3C). Endopod bud present.

Mandibles (Fig. 3D). Right molar now with 3 teeth.

Maxillule (Fig. 3F). Coxal epipod present as 2 setae.

Maxilla (Fig. 3G). Exopod (scaphognathite) margin with 8+4 plumose setae.

First maxilliped (Fig. 3H). Endopod 5-segmented, with 2, 2, 2, 5 setae, respectively; exopod with 8 terminal natatory plumose setae.

Second maxilliped (Fig. 3I). Coxa with seta; exopod with 8 terminal natatory plumose setae.

Pereopod (Fig. 3J). Developing as buds; 1st biramous bud.

Abdomen (Fig. 3K). Six somites.

Telson (Fig. 3K). Unchanged.

Zoea IV

Size: Carapace length 0.61 ± 0.03 mm. Distance from tip of dorsal spine to tip of rostral spine 1.24 ± 0.04 mm.

Carapace (Fig. 4A, E). Three pairs of anterodorsal setae present; ventral margin with 8 setae.

Antennule (Fig. 4B). Exopod with 4 (3 stout+1 thinner) aesthetascs and small seta terminally, with aesthetasc subterminally.

Antenna (Fig. 4C). Endopod bud more developed; exopod with 2 (1 long+1 shorter) terminal setae.

Mandibles (Fig. 4D). Unchanged.

Maxillule (Fig. 4F). Coxal endite with 6 denticulate setae; basal endite with 9 denticulate setae.

Maxilla (Fig. 4G). Coxal endite bilobed, with 5+3 setae; exopod (scaphognathite) margin with 16 plumose setae.

First maxilliped (Fig. 4H). Endopod 5-segmented, with 2, 2, 2, 6 (2 subterminal+4 terminal) setae, respectively; exopod with 10 terminal natatory plumose setae.

Second maxilliped (Fig. 4I). Exopod with 10 terminal natatory plumose setae.

Third maxilliped (Fig. 4J). Biramous; gill present.

Pereopods (Fig. 4K). Some segmental differentiation into segments.

Abdomen (Fig. 4L). Pleopod buds present.

Telson (Fig. 4L). Unchanged.

Zoea V

Size: Carapace length 0.76 ± 0.06 mm. Distance from tip of dorsal spine to tip of rostral spine 1.46 ± 0.08 mm.

Carapace (Fig. 5A, E). Ventral margin with 9 setae.

Antennule (Fig. 5B). Exopod with total of 7 (4 stout+3

thinner) aesthetascs and small seta.

Antenna (Fig. 5C). Endopod enlarged and segmented.

Mandibles (Fig. 5D). Left molar with 2 teeth, confluent with incisor process.

Maxillule (Fig. 5F). Basal endite with 12 denticulate setae.

Maxilla (Fig. 5G). Coxal endite with 7+4 setae; basal endites with 7+5 setae; exopod (scaphognathite) margin with 26 setae.

First maxilliped (Fig. 5H). Coxa with 2 setae; exopod with 12 terminal natatory plumose setae.

Second maxilliped (Fig. 5I). Exopod with 12 terminal natatory plumose setae.

Third maxilliped (Fig. 5J). Unchanged.

Pereopods (Fig. 5K). Segments more prominent.

Abdomen (Fig. 5L). Somite 1 with 3 dorsomedial setae; pleopods 1-4 with biramous endopod buds.

Telson (Fig. 5L). Unchanged.

Megalopa

Size. Carapace length 0.96 ± 0.05 mm. Carapace width 0.80 ± 0.06 mm.

Carapace (Fig. 6A). Quadrangular; rostrum curving downwards.

Antennule (Fig. 6B). Exopod 2-segmented, with total of 11 aesthetascs plus 2 setae; endopod absent.

Antenna (Fig. 6C). Ten-segmented, with 0, 0, 1, 1, 0, 2, 1, 4, 1 and 2 terminal setae.

Mandible (Fig. 6D). Distal segment palp with 4 setae.

Maxillule (Fig. 6E). Coxal epipod present as seta; endopod with 6 marginal setae; coxal and basal endites each with 10 and 17 setae, respectively.

Maxilla (Fig. 6F). Endopod with proximal seta; coxal and basal endites 2-lobed each with 10+4, 9+7 setae, respectively; exopod (scaphognathite) margin with 44 setae, surface with 3 setae.

First maxilliped (Fig. 6G). Endopod with 2 setae; coxal and basal endites each with 8 and 11 setae, respectively; exopod 2-segmented, proximal with 3 terminal setae, distal with 4 terminal plumose setae; epipod with 7 and simple setae.

Second maxilliped (Fig. 6H). Endopod 4-segmented, with 0, 1, 4, and 7 setae, respectively; exopod 2-segmented, proximal with middle seta, distal with 5 terminal plumose setae; epipod absent.

Third maxilliped (Fig. 6I). Endopod 5-segmented, with 9, 8, 4, 4 and 7 setae, respectively; exopod with 2-segmented, proximal with middle seta, distal with 5 terminal plumose setae; epipod with total of 13 setae plus 12 simple setae.

Pereopods (Fig. 6J-N). With numerous setae; dactylus of ambulatory leg 4 with 3 long setae.

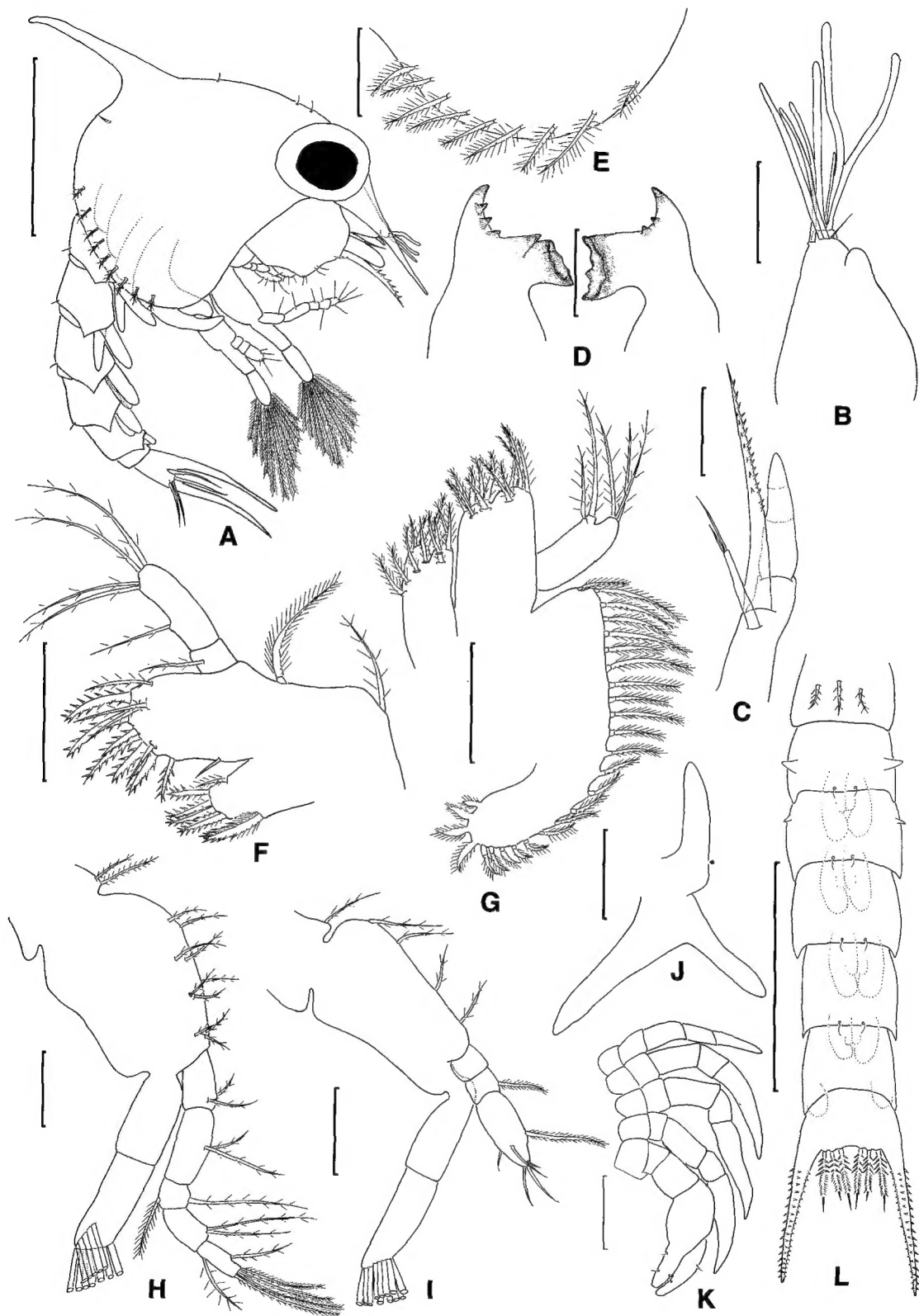


Fig. 5. *Chiromantes haematocheir*, fifth zoeal stage. A, lateral view; B, antennule; C, antenna; D, mandibles; E, lateral expansion of carapace; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped; J, third maxilliped; K, pereopods; L, dorsal view of abdomen and telson. Scale bars=0.5 mm (A), 0.1 mm (B-J), 0.25 mm (K), 0.5 mm (L).

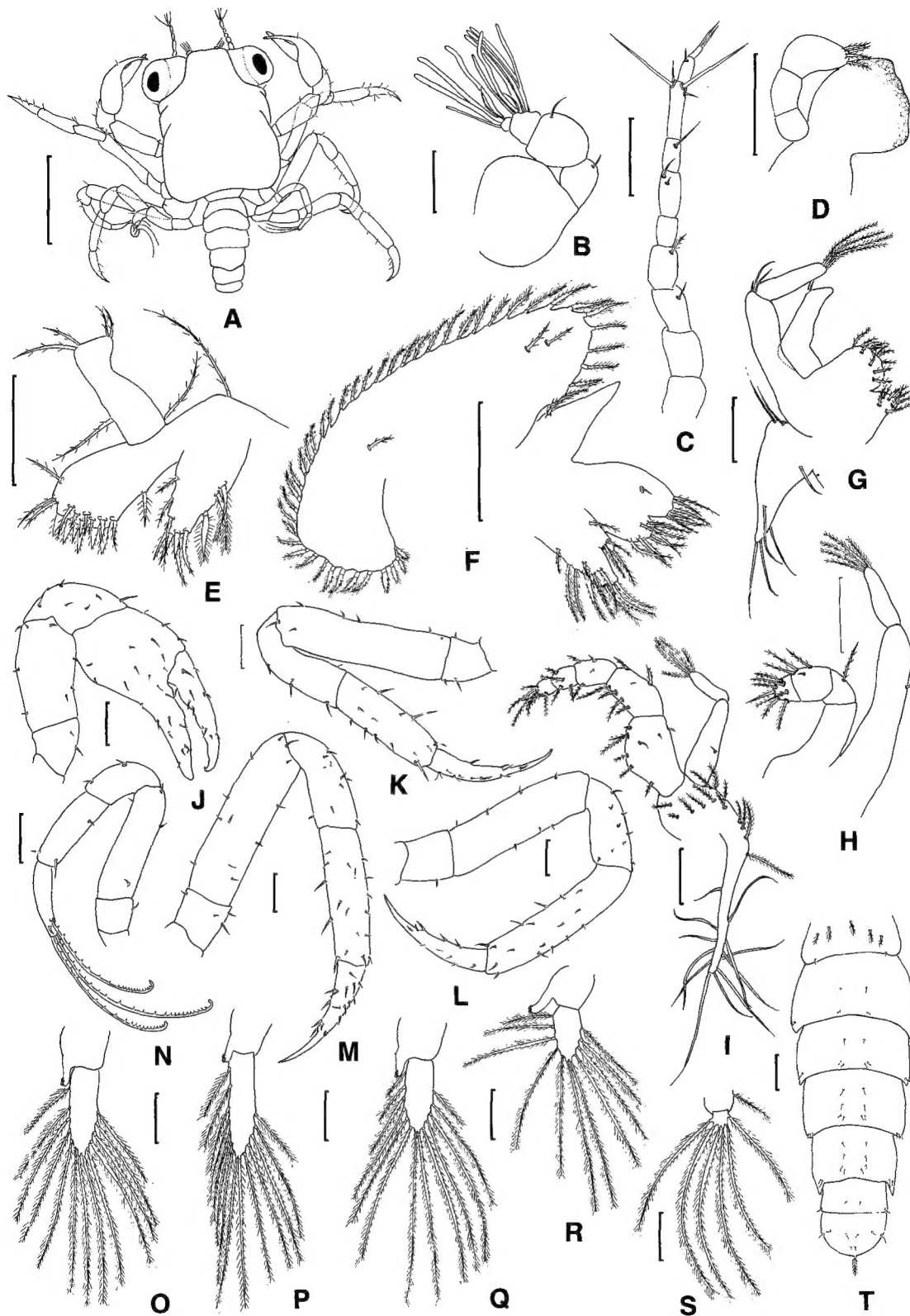


Fig. 6. *Chiromantes haematocheir*, megalopal stage. A, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J, chela; K-N, pereopods 1-4; O-S, pleopods 1-5; T, dorsal view of abdomen and telson. Scale bars=0.5 mm (A), 0.1 mm (B-T).

Table 1. Differences in the larvae of *Chiromantes haematocheir* as described by Lee (1988) and in the present study

Characters	Lee (1988)	Present study
ZOEA I		
Carapace		
anterodorsal	no description	1 pair of setae
posterodorsal	no description	1 pair of setae
Antennule	3 aesthetascs+1 seta	5 aesthetascs+1 seta
Maxilliped I		
coxa	no seta	1 seta
ZOEA II		
Carapace		
anterodorsal	no description	2 pairs of setae
posterodorsal	no description	1 pair of setae
Antennule	3 aesthetascs+3 setae	4 aesthetascs+1 seta
Maxilla		
coxal endite	8 setae	7 setae
Maxilliped I		
coxa	no seta	1 seta
ZOEA III		
Carapace		
anterodorsal	no description	3 pairs of setae
posterodorsal	no description	1 pair of setae
ventral margin	no description	7 setae
Antennule	2 aesthetascs+2 setae	5 aesthetascs+1 seta
Maxillule	1 epipodal seta	2 epipodal setae
Maxilla		
coxal endite	8 setae	7 setae
scaphognathite	13 setae	12 setae
Maxilliped I		
coxa	no seta	1 seta
endopod	2, 2, 2, 2, 6 setation	2, 2, 2, 2, 5 setation
Maxilliped II		
coxa	no seta	1 seta
ZOEA IV		
Carapace		
anterodorsal	no description	3 pairs of setae
posterodorsal	no description	1 pair of setae
ventral margin	no description	8 setae
Antenna		
exopod	3 setae	2 setae
Antennule	3 aesthetascs+1 seta	5 aesthetascs+1 seta
Maxillule		
basal endite	11 setae	9 setae
Maxilla		
scaphognathite	15 setae	16 setae
Maxilliped II		
coxa	no seta	1 seta
Maxilliped III	no description	present as biramous
ZOEA V		
Carapace		
anterodorsal	no description	3 pairs of setae
posterodorsal	no description	1 pair of setae
ventral margin	no description	9 setae
Antennule	4 aesthetascs+2 setae	7 aesthetascs+1 seta
Maxilla		
coxal endite	8 setae	11 setae
scaphognathite	25 setae	26 setae
Maxilliped I		
coxa	1 seta	2 setae
Maxilliped II		
coxa	no seta	1 seta

Table 1. Continued.

Characters	Lee (1988)	Present study
Maxilliped III	no description	present as biramous
Pleopod	uniramous	biramous
MEGALOPA		
Maxillule	2 epipodal setae	1 epipodal seta
basal endite	16 setae	17 setae
coxa endite	12 setae	10 setae
Maxilla		
basal endite	12 setae	16 setae
coxa endite	12 setae	14 setae
scaphognathite	43 setae	47 setae
Maxilliped III		
exopod	3 setae	5 setae
Pleopod I	14 setae	13 setae
Pleopod II	12 setae	14 setae

Pleopods (Fig. 6O-S). Pleopods 1-4 with 13, 14, 13 and 11 plumose setae on distal segment; pleopod 5 with 6 plumose setae on distal segment, with plumose seta on proximal segment.

Abdomen (Fig. 6T). Six-somites; somite 1 with 5 dorsal setae, somites 2-6 with numerous small dorsal setae.

Telson (Fig. 6T). With terminal plumose seta.

DISCUSSION

Lee (1988) described the zoeas of *C. haematocheir*, however, there was no description or illustration about setae of the carapace and the third maxilliped. Also, she had a lack of detail examination about setal presence of the coxa of the first maxilliped and aesthetascs of the antennule in the first zoea. Differences of the characteristics in the larvae of *C. haematocheir* between Lee (1988) and the present study are indicated in Table 1.

The zoeas of the subfamily Sesarminae have been described for 14 species from Korea and adjacent waters. According to Park and Ko (2002)'s key, they were divided into two groups. The first group was composed of the genera *Chiromantes*, *Parasesarma*, *Sesarmops*, *Perisesarma*, and *Nanosesarma* which were characterized by having the endopod of maxilla with 2+3 setae (Aikawa, 1937; Baba and Miyata, 1971; Fukuda and Baba, 1976; Terada, 1976; Terada, 1982; Kim and Ko, 1985; Lee, 1988). The second group included the genera *Cyclograpsus*, *Chasmagnathus*, *Helicana*, and *Helice*, which had the endopod of maxilla with 2+2 setae (Baba and Fukuda, 1972; Baba and Moriyama, 1972; Terada, 1976; Kim and Park, 1983; Baba et al., 1984; Kim and Jang, 1986). However, in the first group the zoeal descriptions are available for eight species (*P. acis*, *P. pictum*, *P. plicatum*, *P. bidens*, *S. intermedius*,

C. dehaani, *C. haematocheir*, and *N. gordonii*). Among them, *P. plicatum* is excluded our discussion because that Fukuda and Baba (1976)'s brief comments without illustrations of it are not adequate for a morphological comparison of zoeas. So, in seven known sesarminid zoeas they show a great similarity as follows: carapace without lateral spine; antennal exopod less than 40% length to protopod, with 2 terminal setae (except in zoeal stages I-III of *C. haematocheir*); endopod of maxillule with 1, 1+4 setae; endopod of maxilla with 2+3 setae; endopod of second maxilliped with 0, 1, 6 setae; lateral processes on abdominal somites 2 and 3; telson fork without outer spine. Hence, it seems to be difficult to identify each other. Therefore, the following provisional key is provided for planktologists to aid in the identification of seven sesarminid zoeas. The characteristics employed are usually consistent during the zoeal development.

Key to seven known sesarminid zoeas in Korea

1. Fork of telson naked 2
– Fork of telson spinulate 4
2. Fork about 62% length of telson; rostral carapace spine \geq length of dorsal carapace spine *Parasesarma acis*
– Fork about 67% length of telson; rostral carapace spine \leq length of dorsal carapace spine 3
3. Antennal exopod about 20% length of protopod *Parasesarma pictum*
– Antennal exopod about 30% length of protopod *Nanosesarma gordonii*
4. Antennal exopod more than 20% length of protopod 5
– Antennal exopod less than 20% length of protopod 6
5. Antennal exopod about 25% length of protopod; rostral carapace spine \geq length of dorsal carapace spine *Perisesarma bidens*
– Antennal exopod about 30% length of protopod; rostral

- carapace spine \leq length of dorsal carapace spine
 *Chiromantes haematocheir*
 6. Antennal exopod about 18% length of protopod
 *Chiromantes dehaani*
 – Antennal exopod about 10% length of protopod
 *Sesarmops intermedius*

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